Patent Application

Of

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For

COMPACT PINLIFTER ASSEMBLY INTEGRATED IN WAFER CHUCK

CROSS REFERENCE

The present application cross references the concurrently filed and commonly owned US Patent Application titled "Compact Wafer Handling System With Single Axis Robotic Arm And Prealigner-Cassette Elevator" by Marc Aho and Daniel Tran, which is hereby incorporated by reference.

FIELD OF INVENTION

The present invention relates to pinlifter assemblies for lifting a wafer from and lowering a wafer onto a wafer chuck. Particularly, the present invention relates to pinlifter assemblies integrated within an outside diameter of a wafer chuck.

BACKGROUND OF INVENTION

During wafer fabrication, wafers are commonly transferred between a wafer chuck and a robotic arm by mechanical devices along a dual positioning axis vertical to the chuck's wafer holding face. The mechanical devices lift/lower a wafer between the chuck's wafer holding face and a loading level, where the wafer may be accessed by a robotic arm for further transportation. Such mechanical devices that employ pins to contact the bottom side or the circumference of the wafer for transfer along the dual positioning axis are commonly referred to as pinlifter assemblies.

A pinlifter assembly needs to be simple and compact while providing a smooth and balanced motion of each pin contacting the wafer. In addition, the pinlifter assembly needs to be designed around other features affiliated with the positioning and holding of the wafer. Such features may include vacuum systems for holding the wafer onto the wafer holding face and precision motion systems for moving the chuck together with the wafer. Such a motion system may be for example an X-Y stage or a rotary stage. All these limiting aspects need to be accounted for by the design of the pinlifter assembly. At the same time, the pinlifter assembly is desirably compact and highly integrated in the wafer chuck. The present invention addresses this needs.

SUMMARY OF INVENTION

A compact pinlifter assembly is fitted in a substantially enclosed cavity within a wafer chuck such that an overall outside shape of the wafer chuck remains highly unaffected. The pinlifter assembly includes wedge guides providing a movement path in a wedge angle relative to the wafer holding face. A pin actuator is driven along the wedge guides transforming its movement along the wedge guides into a vertical movement of the lifting pins perpendicularly sliding between the cavity and the wafer holding face.

The combination of wedge guides and pin actuator takes advantage of the relatively large lateral dimensions of the wafer chuck to move the pin actuator between end positions that are in a distance multiple of the pin lifters movement. Due to the wedge angle, the

actuators comparatively large scale movement is transformed in a highly precise, smooth and balanced movement of the pin lifters.

An actuator drive preferably employs a stepper motor, a reduction gear mechanism and a connecting rod transforming the rotational movement of the actuator drive into a linear movement of the pin actuator.

The pin actuator provides recesses and a cutout for all involved components as well as for an eventual vacuum connect vertically propagating across the cavity. The cavity itself may be hermetically sealed and operate itself additionally as a vacuum connect.

DESCRIPTION OF THE FIGURES

Fig. 1 is a perspective view of a wafer testing device with a wafer chuck in accordance with the preferred embodiment of the invention.

Fig. 2 is a top perspective view of the wafer chuck of **Fig. 1**.

Fig. 3 is a front view of the wafer chuck of **Fig. 1**.

Fig. 4 is a bottom perspective view of the wafer chuck of **Fig. 1**.

Fig. 5 is a bottom perspective view of the wafer chuck of **Fig. 4** with the base lid removed and showing the chuck cavity with mounted guide structures and pinlifters extending with their bottom faces into the cavity.

Fig. 6 is a bottom perspective view of the wafer chuck of **Fig. 5** illustrating additionally the pin actuator, actuator drive and connecting rod.

Fig. 7 is a top perspective view of guide structures, pinlifters, pin actuator and actuator drive in assembled position.

DETAILED DESCRIPTION

In accordance to **Fig. 1**, an exemplary wafer testing device **1** may be a well known spectrometer, reflectometer or other well known wafer testing device in which a well known wafer is moved and positioned with high precision beneath and relative to a measurement head **42**.

The wafer testing device **1** may have a housing **11** combined with a base **2**. The housing **11** may have any suitable configuration for providing structural support and for integrating additional well known components such as, for example, electrical and other supply devices, control computers and other devices that are well known parts of optical measurement devices.

The base **2** holds a measurement assembly **4** which may include a head carrying arm **41** and the measurement head **42**. Attached to and carried by the base plate **2** is a stage system **3** including for example a high precision linear X-stage **31** and a high precision linear Y-stage **32**. X-stage **31** and Y-stage **32** may be combined in a single commercially available device. On top of the stage system **3** is a chuck **5** for receiving and fixedly holding a wafer (not shown) during measurement.

Referring to **Fig. 2**, the chuck **5** may have a chuck body **51** featuring a wafer holding face **510,** which is fabricated with high planarity and smoothness for receiving and holding a wafer. The holding face **510** may be interwoven by communicating vacuum grooves **512** for distributing a vacuum across the holding face **510**. The vacuum may be used in a well known fashion to temporarily fix the wafer on the holding face **510**. The vacuum grooves **512** are accessed by a vacuum channel **513** that propagates across the chuck height **CH** (see **Fig. 3**).

The chuck body **51** further features at least three but preferably four pin channels **518** preferably concentrically arranged with respect to a center axis **CA** of the chuck **5**. The pin channels **518** are substantially perpendicular to the wafer holding face **510** and are correspondingly shaped to pinlifters **53** (see **Figs. 5, 7**). The pinlifters **53** are slide ably embedded in the pin channels **518** for lifting and lowering a wafer with respect to the wafer holding face **510**. Each pinlifter **53** has a top face **531** and a bottom face **532** (see **Fig. 5**). In **Fig. 2**, the pinlifters **53** are shown in a bottom position, in which the top faces **531** are below the holding face **510**.

As seen in **Figs. 3, 4**, the chuck **5** has preferably a rotationally symmetric outside shape with an outside diameter **OD** that preferably corresponds to a diameter of a wafer intended to be placed on the chuck **5**. The majority of the chuck's **5** structure is contributed by the chuck body **51.** The chuck body **51** is preferably monolithically fabricated from a thermally stable and wear resistant material such as granite. The chuck **5** may have a base diameter **BD** that is recessed from the outside diameter **OD**. A base lid **52** may be attached at the bottom to the bottom of the chuck body **51** with lid screws **521**. A vacuum connect **515** may extend through the base lid **52** for connecting a vacuum to the vacuum channel **513**.

As seen in **Figs. 5, 6, 7,** a cavity **516** is placed below and structurally separated from the holding face **510**. The pin channels **518** extend between the holding face **510** and the cavity **516**. Embedded in the cavity is a pinlifter assembly including the wedge guides **542**, pin actuator **55** and driving members **56, 57**. The wedge guides **542** are preferably provided by guide structures **54** preferably attached in the cavity **516** via guide screws **545**. In **Figs. 5, 6**, the guide structures **54** are shown as being attached to chuck body **51** but may be additionally and/or alternatively attached to the base lid **51**.

The scope of the invention includes embodiments, in which the cavity **516** is at least partially provided by secondary structural components of a rotary stage, a single axis linear stage, a dual axis linear stage or any other movement device well known for

precision positioning a wafer fixed to a chuck. In such embodiments, the lid **52** may be substituted by the secondary structural components. Also in such embodiments, the guide structures **54** may be attached to the secondary structural components. Particularly in the case of a rotary stage, the guide structures **54** may be attached to a non rotating portion of the rotary stage whereas the chuck body **51** is attached to a rotating portion of the rotary stage.

In other embodiments, the wedge guides **542** may be formed into the chuck body **51** and/or the base lid **51** as integral part of the cavity **516**. In such cases, the guide structures **54** are omitted.

The pin actuator **55** has sliding features **552** correspondingly shaped to the wedge guides **542** and is slide ably guided by said wedge guides **542**. The sliding features **552** may be configured in any well known fashion such as snuggly fitting profiles, line contacting glide pins or rollers.

The pin actuator **55** has a rod connect **557** via which the pin actuator **55** receives a driving force from a connecting rod **57**. The connecting rod **57** in turn is hinged between the rod connect **557** and a motored rotating crank **567**. The rotating crank **567** is part of actuator drive **56**, which may preferably include a stepper motor and an optional reduction gear. In case where the stepper motor drives the rotating crank directly, actuator drive **56** includes the stepper motor alone.

The stepper motor is particular suitable as a motoring device to be embedded inside a shallow cavity since it may be readily and commercially available in configurations with low extension along its rotation axis **RA**. In such case, the stepper motor may be embedded in the cavity with its rotation axis **RA** substantially perpendicular the holding face **510**.

The scope of the invention includes embodiments, in which the pin actuator **55** may be alternatively driven by a gear rotated by the actuator drive **56** and engaging with a gear rack attached to the pin actuator **55**.

The wedge guides **542** are preferably linear. In alternate embodiments, the wedge guides **542** may be circular and rotationally symmetric arranged such that the movement path is a rotation. In such case, the wedge guides **542** may be arranged such that a rotation axis of the movement path substantially coincides with the center axis **CA**. Also in such case, the gear rack described for embodiments in the paragraph above may be a conventional gear as may be well appreciated by anyone skilled in the art.

The vacuum connect **515** protrudes across the cavity **516**. To avoid interference between the pin actuator **55** moving between its two opposing end positions, the pin actuator **55** has a cutout **555**. The pin actuator **55** may also have recesses **556** to avoid interference with driving members such as connecting rod **57** and actuator drive **56**. The pin actuator **55** may feature additional lateral actuator faces **551** that correspond to guide faces **541** for an eventual additional horizontal guiding of the pin actuator **55** along its movement path.

The pinlifters **53** rest with their respective bottom faces **532** on a pin contact face **550** of the pin actuator **55** such that the pinlifters **53** are simultaneously moved along pin channels **518** and the top faces **531** are moved between a bottom position below the holding face **510** and a top position above the holding face while the pin actuator **55** is moved along the movement path. The pinlifters **53** may rest spring loaded and/or gravity loaded on the contact face **550**.

The top position preferably corresponds to a loading level at which the wafer may be accessed from beneath by a robotic arm for further transfer away from the chuck **5**. For that purpose, the pinlifters **53** may be lowered again once the robotic arm is in loading position such that the weight of the wafer is transferred from the top faces **531** onto the robotic arm. Likewise and in an opposite sequence of steps, the pinlifters **53** may be moved into their top position while a wafer is held in position above the wafer holding

face **510**. The pinlifters **53** may be moved by locically and/or computerized controlled powering the actuator drive **56** in a well known fashion. Within a wafer testing device **1** such as described in the concurrently filed and cross referenced application titled "Compact Wafer Handling System With Single Axis Robotic Arm And Prealigner-Cassette Elevator" the pinlifter **53** movement may be defined as a movement along dual positioning axes **DP**. In such testing device **1**, the controlled powering may be accomplished by a control system of the testing device **1**.

In the preferred embodiment, the pin contact face **550** is substantially coplanar with the holding face **510** while the pin actuator **55** is moving along the movement path. In alternate embodiments, the wedging effect between the pin actuator **55** and the pin lifters **53** may be provided by the pin contact face **550** tilted with the wedge angle **WA** relative to the pin actuator's **55** movement path. In such alternate case, the pin actuator **55** may be moved substantially horizontally.

In another embodiment, the cavity **516** may be substantially sealed such that a vacuum may communicate substantially unimpeded across the cavity **516**. In that case, the vacuum connect **515** may extend from the cavity's **516** bottom and the core of the cavity **516** may remain free of any vacuum transmission structure that may limit the design of the pinlifter assembly.

Accordingly, the invention described in the specification above is set forth by the following claims and their legal equivalent: